GOWIN 22nm FPGA SER Test Report

Scope

This paper summarizes the test result of SER for GOWIN 22nm FPGA devices.

Background

GOWIN's FPGA devices are SRAM based, which means the user logic is programmed and controlled by internal configuration SRAM cells. A Single event upset of an SRAM cell, introduced by Alpha particles or Neutron particles, is well understood by the industry and needs to be considered in system failure rate calculations for mission critical, functional safety, and high reliability applications.

Test Procedure

Tested SRAM

The number of SRAM cells can be derived from the bitstream file. The bitstream file contains all the data needed to be programmed into FPGA SRAM cell array. Therefore, from array size, we should be able to obtain the SRAM cell number. Such array includes 2 types of SRAM cells: one is the configuration SRAM; the other is the block SRAM that users utilize for memory storage in their designs which is not involved the logic control.

Table 1 and Table 2 show the soft error rates caused by single event upsets (SEUs) affecting memory cells used as configuration SRAM and block SRAM.

Test Methods

Neutron cross-section are determined from CSNS beam testing according to JESD89/6 Accelerated High-energy Neutron Test Procedure, and the thermal neutron cross-section according to JESD89/7 Accelerated Thermal Neutron Test Procedure. The neutron soft error rate (in FIT/Mb) is corrected for New York City.

Alpha particle cross-section is determined by Americium-241 source as alpha radiation source according to JESD89/5 Accelerated Alpha Particles Test Procedure, and the alpha soft error rate (in FIT/MB) is corrected based on alpha emissivity 0.001 counts/cm^2/hr.

Soft Error Rates for Configuration SRAM

Table 1 shows the soft error rates caused by single event upsets (SEUs) affecting memory cells used as configuration SRAM.

Table 1 Soft Error Rates for Configuration SRAM[1] [2]

Tech Node	Product Family	CSNS Neutron[3]			Thermal Neutrons			Alpha Particle (Actual)[4]		
22nm	Arora V	Cross-section(cm^2/bit)	FIT/Mb[5]	std dev	Cross-section (cm^2/bit)	FIT/Mb[5]	std dev	Cross-section (cm^2/bit)	FIT/Mb	std dev
		$4.30*10^{-15}$	58.6	2	$1.80*10^{-15}$	12.3	7	$1.69*10^{-11}$	17.7	2

Note!

- [1] Experiments are performed on GW5A-25 product, with the numbers of 650 Kbytes SRAM.
- [2] Experiments are performed at ambient temperature with typical power supply voltages.
- [3] Data from China Spallation Neutron Source (CSNS)*.
- [4] Typical alpha data is based on alpha emissivity of 0.001counts/cm^2/hr.
- [5] Neutron soft error rates (in FIT/Mb) are corrected for New York City, according to JESD89A.
- [6] During the test with the ECC function on, all SEUs detected during the test were corrected, the SER is 0.

ECC for Configuration SRAM

Gowin 22nm FPGAs provide ECC function, an experimental group was set up for ECC function capability verification.

Under the same FLUX experimental conditions, with the SRAM readback frequency of 15MHz and the readback and comparison period of 44610us, SEUs can be observed during the readback process, in which SBUs are observed while no MBU is found. All observed SBUs are corrected by ECC circuitry, and the whole bitstream is maintained to allow the device to work normally.

Soft Error Rates for Block SRAM

Table 2 shows the soft error rates caused by SEUs affecting memory cells used as Block SRAM.

Table 2 Soft Error Rates for Block SRAM[1] [2]

Tech Node	Product Family	CSNS Neutron[3]			Thermal Neutrons			Alpha Particle (Typical) [4]		
22nm	Arora V	Cross-section(cm^2/bit)	FIT/Mb[5]	std dev	Cross-section (cm^2/bit)	FIT/Mb[5]	std dev	Cross-section (cm^2/bit)	FIT/Mb	std dev
		$1.34*10^{-14}$	165.0	22	$1.16*10^{-14}$	79.3	30	$9.63*10^{-11}$	101.3	7

Note!

- [1] Experiments are performed on GW5A-25 product, with the numbers of 126 Kbytes SRAM.
- [2] Experiments are performed at ambient temperature with typical power supply voltages.
- [3] Data from China Spallation Neutron Source (CSNS)*.
- [4] Typical alpha data is based on alpha emissivity of 0.001counts/cm^2/hr, actual
- [5] Neutron soft error rates (in FIT/Mb) are corrected for New York City, according to JESD89A.

Functional Interrupt Rate Estimation

The functional interrupt rate is directly correlated with the SRAM SER. Table 3 provides a configuration SRAM size for evaluating the risk of functional failure. However, only critical bits should be considered, as user logic designs implemented rely on a small fraction of critical bits in the SRAM in order to ensure proper operation.

Table 3 Configuration SRAM Size

Tech Node	Product Family	Device	Configuration SRAM Size (Mbits)
22nm	Arora V	GW5AT-15	3.33
		GW5A-25 / GW5AR-25	5.08
		GW5A-45	Under design
		GW5AT-60	11.97
		GW5AT-75	31.56
		GW5A-138 / GW5AT-138 GW5AS-138 /GW5AST-138	31.56

*China Spallation Neutron Source (CSNS)

It is a dedicated atmospheric neutron irradiation test platform based on the China Spallation Neutron Source. It provides an atmospheric neutron beam with the same spectrum as recommended by international standards can carry out atmospheric neutron irradiation test and evaluation of electronic devices/modules/systems for aviation equipment.

Support and Feedback

Gowin Semiconductor provides customers with comprehensive technical support. If you have any questions, comments, or suggestions, please feel free to contact us directly using the information provided below.

Website: www.gowinsemi.com

E-mail: support@gowinsemi.com

Revision History

Date	Version	Description
09/15/2023	1.0E	Initial version published.
10/31/2023	1.1E	Add Functional Interrupt Rate Estimation & CSNS profile

Disclaimer

GOWINSEMI assumes no liability and provides no warranty (either expressed or implied) and is not responsible for any damage incurred to your hardware, software, data, or property resulting from usage of the materials or intellectual property except as outlined in the GOWINSEMI Terms and Conditions of Sale. GOWINSEMI may make changes to this document at any time without prior notice. Anyone relying on this documentation should contact GOWINSEMI for the current documentation and errata.